FORESTRY

FRDA REPORT 152

Gel Cap® Demonstration Trials Throughout British Columbia

by
J. C. Bartlett

FOREST RESOURCE DEVELOPMENT AGREEMENT

Canada

BC

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EXECUTIVE SUMMARY

In 1987, Pace Chemicals Ltd. and Forestry Canada entered into a Direct Delivery, Forest Resources Development Agreement (FRDA) project (#F-52-42-102) in order to evaluate the herbicide technique "Gel Cap®*".

Gel Cap® was designed to control young trees, typically hardwood species, such as red alder and aspen. It is a capsule injection system, consisting of a capsule containing gelled herbicide, and an applicator tool. The capsule is an open-ended plastic cylinder containing 0.36 grams of the active ingredient glyphosate. The capsule is screwed into a tree, thereby exposing the gelled herbicide to the cambial tissues.

The herbicide is dissolved in, and diffuses into, the tree's conductive fluids, and causes mortality. Efficacy data has been prepared by the B.C. Hydro (H.M. Ellis, 1987, Instructions for Participants in the Herbicide Capsule Evaluation Program), which supports the label information prepared by Monsanto for their products (i.e. Vision and Round-Up).

Four trials were established throughout B.C. in order to demonstrate and evaluate Gel Cap® efficacy and productivity, while comparing it to a Hack and Squirt method (H & S).

Gel Cap® is best suited for trees less than 12 cm dbh (diameter breast height) and on trees of this size, 93% efficacy was achieved. Mortality of trees treated with Gel Cap® occurred gradually throughout the growing season, whereas it was rapid with H & S. This slow rate of kill benefits conifer release and the establishment of low vegetation on utility rights-of-way, and is visually less offensive.

Terrain and stem density of target stems has an influence on productivity. Gel Cap® productivity averaged 10.8 man-hours per hectare, which was greater than H & S at 12.5 man-hours per hectare.

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*®Registered Trade Mark, Pace Chemicals Ltd.

The benefits of the Gel Cap® system shown in the demonstrations were:

- No chemical exposure to the workers or the environment.
- Minimal application training and safety concerns.
- Increased application season, including the dormant season, and fewer application delays from inclement weather conditions (i.e., greater application "window").
- Suitability for use within biologically or politically sensitive areas, such as riparian zones, urban rights-of-way, or municipal watersheds.
- Decreased rate of mortality benefits the remaining crop trees or vegetation where sun scald or sudden exposure to the elements is a concern.

INTRODUCTION

In 1987, Pace Chemicals Ltd. and Forestry Canada entered into a Direct Delivery, Forest Resources Development Agreement (FRDA) project (#F-52-42-102) in order to evaluate the herbicide technique "Gel Cap®".

Gel Cap®, is a vegetation management technique, designed and developed for controlling unwanted tall growing trees, by B.C. Hydro and PACE CHEMICALS LTD. It is a capsule injection system, consisting of a capsule containing a herbicide, and an applicator tool for affixing the capsule to a tree.

The capsule is an open-ended plastic cylinder approximately 15 mm in diameter and 21 mm in length (see Figure 1). The capsule contains 1.0 ml of a gelled herbicide (Vision or Round-Up Monsanto), which contains 0.36 grams of the active ingredient glyphosate. The capsule is applied to a tree, using a specially designed socket (capsule driver) fitted to a battery-powered drill (see Figure 2). A screw, housed within the capsule, is driven into the tree and draws the leading edge of the capsule into the bark, thereby exposing the gelled herbicide to the cambial tissues. Through this process the herbicide is sealed to the tree and cannot escape into the surrounding environment (see Figure 3).

The herbicide is dissolved in, and diffuses into the tree's conductive fluids, causing mortality. Efficacy data has been prepared by the B.C. Hydro (H.M. Ellis, 1987, Instructions for Participants in the Herbicide Capsule Evaluation Program), which supports the label information prepared by Monsanto for their product Vision.

Gel Cap® was designed for thin barked (i.e. 2 mm or less) young trees within a diameter range of 2-12 cm dbh (diameter breast height). Hardwood species such as red alder and aspen (poplar) and young coniferous species are typically suited to this technique. White birch is not suitable due to the nature of its bark, which restricts capsule penetration in all but the very young trees (i.e. less than 4 cm dbh).

Figure 1. Gel Cap® capsule

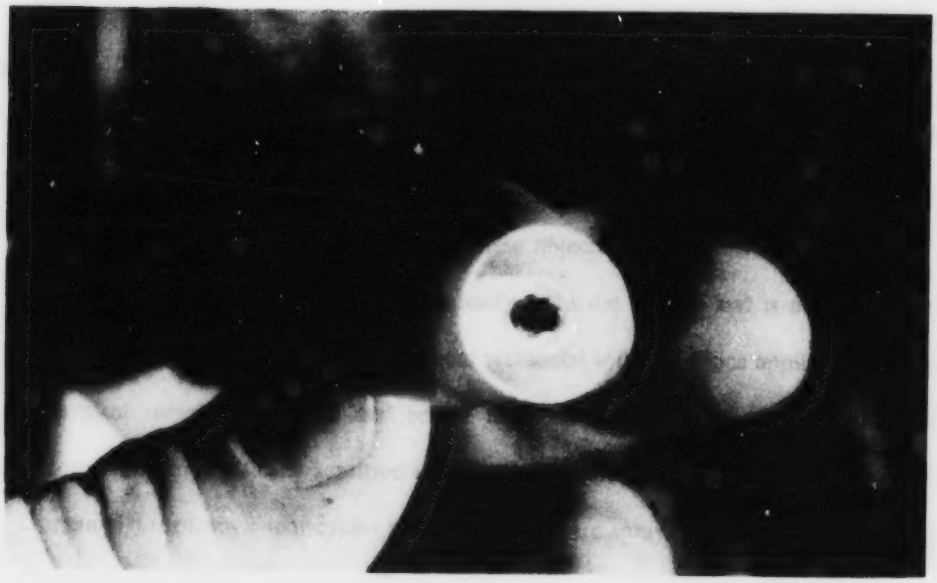


Figure 2. Application of Gel Cap®

The Gel Cap® capsule injection system has the following key features in forestry applications:

1. Selectivity: It is a selective technique, whereby only the target tree is removed. This may be useful where the site objective is to retain some of the target species or for thinning operations. Spray systems cannot serve these objectives.

2. Environmental: The herbicide is contained within the capsule and is not exposed to the environment; thereby keeping it safe from accidental spillage. Once applied to the tree the chemical remains contained and sealed from the environment. It is well suited for biologically or politically sensitive sites such as riparian zones, watersheds, woodlots, or urban rights-of-way. It provides an alternative where spraying or hack and squirt systems are not desirable.

3. Operational flexibility: Once applied the chemical is sealed from the environment and remains in its gelled formulation until the tree becomes active. Application is possible when the target species is dormant and/or during rainy or adverse weather; since there are no losses or exposures of the chemical into the environment during these times. Hack and squirt or spray systems cannot provide these options. The Gel Cap® system provides this greater "window" of operations, hence greater crew and contractor flexibility.

4. Safety: Workers' Compensation Board suggests there are minimal concerns, especially compared to other application techniques:

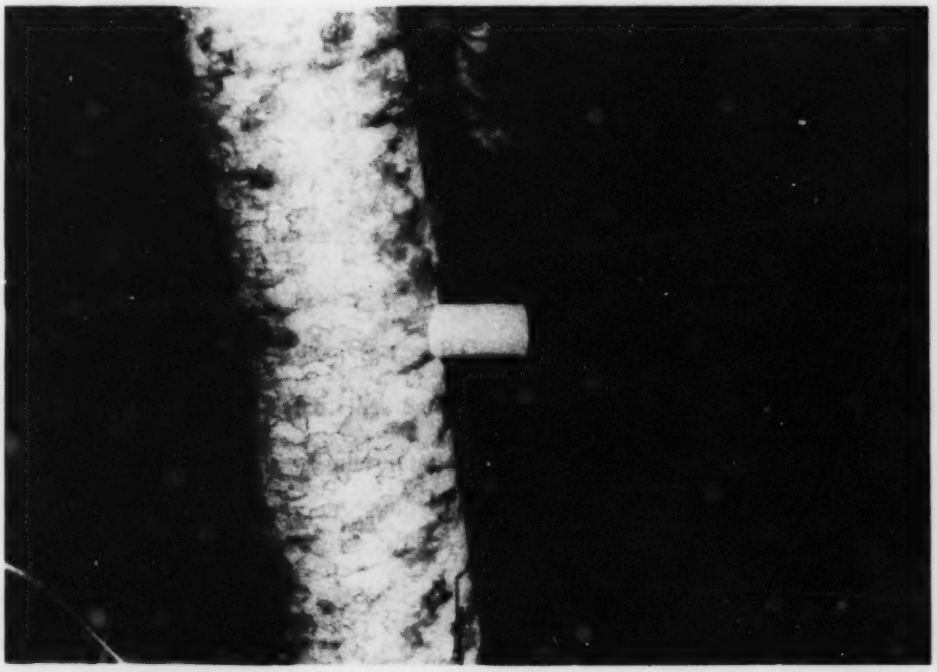
   - no applicator exposure to the herbicide, either through mixing, inhalation, or application. The worker should only require protective gloves.
   - no potentially dangerous tools such as axes or power tools.
   - less operator fatigue and its related increased risk of injury from other tools.

5. Simplicity: Requires a minimum of training concerning application methods and safety techniques. The tools are reliable and simple to operate in the field.

6. Mortality pattern: Treated trees die gradually throughout the growing season after treatment, not within a period of weeks, as with other systems.

- Reduces crop tree and vegetation stress and sudden exposure problems (e.g., sun scald) due to a gradual adjustment to the increased sunlight and temperature.
- Reduces the short-term fire hazard, such as along roadsides or for fuel breaks in pre-commercial thinning.
- Reduces visual impact to the public.

Figure 3. An applied Gel Cap®



OBJECTIVES:

The objectives of the trial were to demonstrate and evaluate Gel Cap® as a herbicide delivery technique for controlling undesirable tree vegetation.

1. To demonstrate Gel Cap® as an operational vegetation management tool to the forestry community in B.C.
2. To establish demonstration sites of Gel Cap® throughout B.C.
3. To evaluate productivity rates and associated costs of Gel Cap® and a conventional hack and squirt (H & S) method.
4. To expand upon the existing efficacy data base of Gel Cap® using the product Vision (Monsanto).

METHODS:

1. Four demonstration sites were established and signs posted (Figure 4) at the following locations (maps are presented in Appendix I):
    1. University of British Columbia Research Farm (UBC Farm), Oyster River, B.C. (Vancouver Island).
    2. University of British Columbia (UBC Forest), Malcolm Knapp Research Forest, Haney, B.C.
    3. Pelican Road, Prince George, B.C.
    4. Ivy Lake and Larch Hills, Salmon Arm. Figure 5 illustrates a sign posted on a Ministry of Forests interpretation trail at the Larch Hills Cross Country Ski Site.

Figure 4. Typical sign at a demonstration site

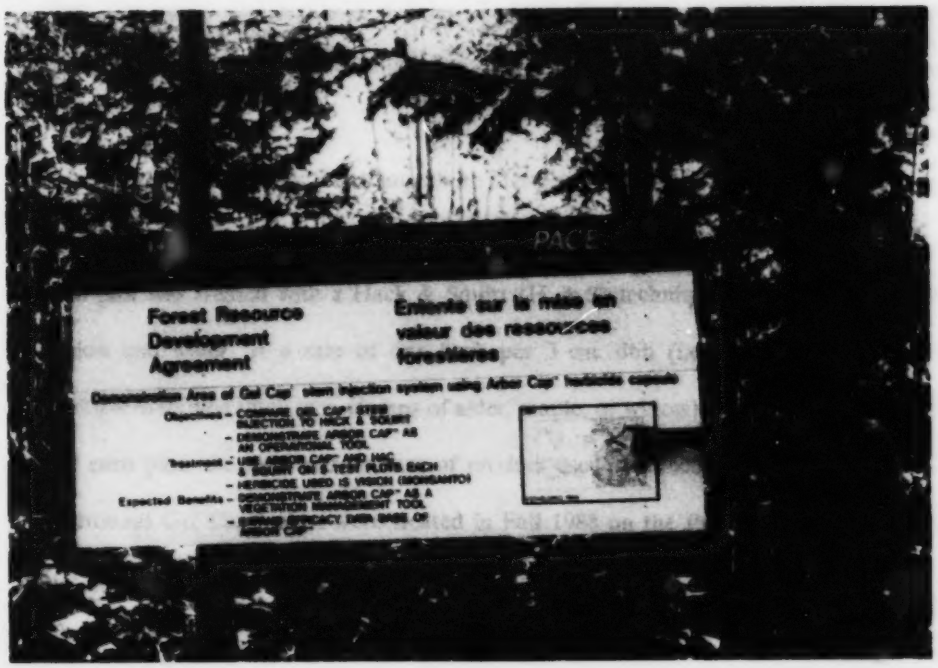
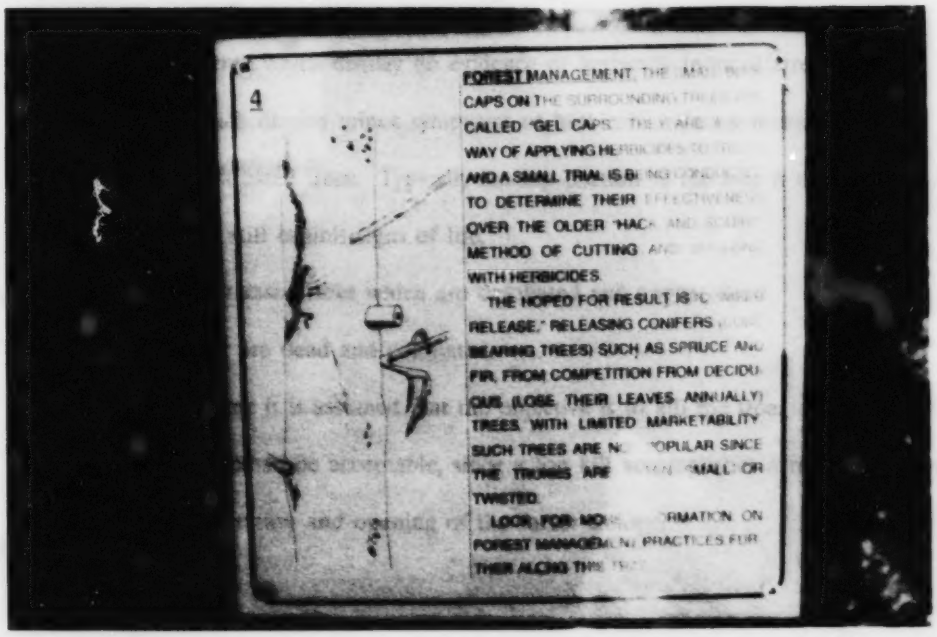


Figure 5. B.C. Ministry of Forests interpretation sign



2. Each site was established with 5 pairs of plots. Each plot was 20 m x 20 m (400 m^2), within which was a 100 m^2 circular plot. Each target species within the 100 m^2 plot was tagged.

3. One of each pair of plots was treated with Gel Cap® in Spring 1988, at a rate of 1 capsule for 2-6 cm dbh, 2 for 7-12 cm dbh, and 3 for 13-18 cm dbh. The remaining plot from each pair was treated with a Hack & Squirt (H & S) technique, using a 50% solution of Vision and water, at a rate of one hack per 3 cm. dbh (i.e. 1 ml product/6 cm. dbh). Multiple-stemmed trees (e.g. clumps of alder, maple, or willow) were treated on each stem.

4. For each plot, the time and amount of product used was recorded.

5. Additional Gel Cap® plots were treated in Fall 1988 on the Prince George, Salmon Arm, and UBC Forest sites.

6. Demonstrations were held at each site throughout the project.

7. Efficacy data was recorded from the tagged target sample trees within each plot. The first and second growing season treatment results on the sample trees were recorded, using a condensed version of a B.C. Hydro classification system (see below), referred to as the "foliar index scale" (H.M. Ellis, 1987. Instructions for Participants in the Herbicide Capsule Evaluation Program, B.C. Hydro, Research and Development, Surrey, B.C.):

   0. Healthy tree which display no evidence of herbicide induced stress.

   4. Trees which display minor symptoms of herbicide induced stress.

   7. Severely stressed trees. Typically the top portion of the tree is dead, but some of the limbs still exhibit signs of life.

   8. Severely stressed trees which are defoliated and appear dead.

   9. Trees that are dead and defoliated.

   In this rating scheme it is assumed that the objective is to kill the tree. A rating of "7" or greater is considered to be acceptable, since a top kill accomplishes arresting the vertical growth of the vegetation and opening of the forest canopy.

8. Tests of significance for productivity (hours/ha) and efficacy were performed using a t-test for paired plots.

RESULTS AND DISCUSSION:

Labour Productivity

Productivity was measured as the number of man-hours to treat one hectare (see Appendix II, Table 2). The average number of capsules fastened per hour was 385, with a range of 295 to 520. Ellis (1987) reported a figure of 500 capsules per hour using contract crews on a B.C. Hydro right-of-way. Considering these trials only treated 0.8 hectares, and productivity was secondary to efficacy, a figure of 500 capsules per hour appears to be a realistic average. On the UBC Farm and the Salmon Arm sites, the Gel Cap® had significantly greater productivity than H & S; whereas there was no significance between the systems on the UBC Forest and Prince George sites. Both the UBC Forest and Prince George had plots with greater than 3500 stems per hectare. (See Appendix II, Tables 3 to 6).

From the data it was surmised that for less than 3500 stems per hectare, the Gel Cap® system will be 25 to 35% more labour efficient than the H & S system. The Salmon Arm site is typical of this scenario, where the average diameter was 6 cm (range 3-10) and the average stems per hectare was 2250 (range 900-3000). Productivity increases for the Gel Cap® system with an increase in the proportion of stems 6 cm dbh or smaller, since they require only one capsule.

The experimental design required all stems 2 cm or greater in diameter to be treated. The Prince George site contained numerous multiple-stemmed clumps of alder and willow which were treated with the Gel Cap® system. Safety concerns and practicality denied the use of the H & S system on these clumps. On the Prince George site, this factor negatively affected the Gel Cap® productivity, product consumption, and its costs. With an operational forestry application, the clumps on this site would have been left since they were not competing with the crop trees. On sites where the primary target is small diameter and/or, multiple-stemmed trees, Gel Cap® is safer for the applicator, operationally feasible, and more efficacious than the H & S system. MacMillan Bloedel Ltd. (Franklin River Division) established an operational trial, where these features were observed.

Product Consumption

Referring to Table 2 (Appendix II), the product (i.e. VISION (Monsanto)) average consumption per hectare using Gel Cap® was 58% more than for H & S. Gel Cap® consumption averaged 4140 ml of VISION (Monsanto) per hectare and the H & S method used 2615 ml. An explanation for this may be found in the "Methods" of the trial and the structural differences between the 2 systems (i.e., one capsule for trees 2-6 cm dbh and 2 capsules for trees 7-12 cm dbh, or 1 hack and squirt per 3 cm of diameter, with a 50% solution of VISION and water). As an example, a 9 cm dbh tree required 2 capsules (i.e. 2 ml of product) vs. 3 hacks and squirts (i.e. 1.5 ml of product); but 3 cm dbh trees required 1 capsule (i.e., 1 ml of product) vs 1 hack and squirt (i.e., 0.5 ml of product). Only trees with a dbh of 6 cm and 12 cm will use an equal amount of product. In stands where the average diameter is 6 cm (range 3-10), such as the Salmon Arm site, half of the stems will be greater than 6 cm and will require 2 capsules or 3 hacks and squirts. When this factor is combined with a high number of stems per hectare, such as the Prince George site, the difference in product consumption between the two systems increases.

Costs

The average cost per hectare of the treatments was $960 for Gel Cap® and $285 for H & S. A large portion of the Gel Cap® cost is the amount of capsules required (as discussed in "Production Consumption"). The greater the number of stems requiring only one capsule, the more comparable the amount of product between the two systems will be, and the productivity will become proportionally higher for the Gel Cap® system. As this scenario is approached, in association with less than 3500 stems per hectare, the cost differences between the Gel Cap® and H & S systems diminish substantially.

Reaction Time to Treatment

It was evident from all the test sites, mortality using Gel Cap® was slower than H & S. When all sites were viewed approximately 2 months after treatment, the Gel Cap® plots were

beginning to exhibit herbicide induced stress. In contrast, the H & S plots were virtually dead, and obviously had been for some time. Concurrently, the salmonberry at the UBC Forest site was suffering from considerable damage to its foliage on the H & S plots, probably due to the rapid increase of light. The salmonberry on the Gel Cap® plots was not affected in this manner.

The slow nature of the Gel Cap® kill is a consideration for conifer release, whereby the trees may gradually adjust to the increased light and temperature conditions. Balsam (Abies lasiocarpa) is typically susceptable to sudden exposure to sunlight.

The slow kill during the growing season after treatment has positive fire protection implications which may be desirable for fuel breaks among brush-saw, brushing and weeding, thinning activities, or along roadsides and rights-of-way.

Similarly the slow kill is less visually dramatic to the public in areas where public reaction is a concern. The hardwood target stems typically show mortality as fall approaches and leaf drop normally occurs. This allows time to develop management strategies to achieve aesthetically pleasing results in urban areas for example.

Efficacy

The efficacy was measured using the "foliar index scale" outlined in the "Methods". In Table 7 (Appendix II), the efficacy of Gel Cap® averaged 93%, excluding the UBC Farm data. The efficacy of H & S was consistently high, with an average of 100%. The Gel Cap® efficacy, although at an acceptable level, was less than the H & S system; however, the UBC Forest and the Salmon Arm sites have no significant difference between treatments.

The UBC Farm data was unique due to the large diameter (average 12 cm, range 7-20 cm dbh) of the stems treated. The stems on this site confirm that treating trees beyond the design capabilities of Gel Cap® (i.e., 12 cm dbh) produces inconsistent results and the maximum limit is 15 cm dbh. Trees beyond 12 cm dbh require bark removal prior to attaching the Gel Cap® to achieve consistent mortality, or attaching the Gel Cap® around the perimeter of a freshly cut stump.

Fall treatments (mid-September) of the Prince George, UBC Forest, and Salmon Arm sites all exhibited 100% efficacy with Gel Cap®, indicating a seasonal preference exists and should be considered if efficacy greater than 93% is required. There was no UBC Farm fall treatment.

CONCLUSIONS

1. This trial compared the Gel Cap® herbicide system to a conventional Hack and Squirt (H & S) system, both using the herbicide VISION (Monsanto), at 4 locations in B.C. Parameters compared were efficacy, productivity, and costs.
2. The UBC Farm site confirmed Gel Cap® should be used to control trees less than 12 cm in diameter, after which bark thickness becomes the limiting factor. H & S is unaffected by bark thickness.
3. On the three sites where the average stem diameter was less than 12 cm, the Gel Cap® efficacy average was 93% for the spring treatments, and 100% for the fall treatments.
4. Gel Cap® productivity ranged from 295 to 520 capsules per hour, with an average of 385. The average number of man-hours per hectare was 10.8 for Gel Cap® and for H & S was 12.5. Productivity is sensitive to target stem density.
5. Mortality on trees treated with Gel Cap® occurred gradually throughout the growing season after treatment. On trees treated with H & S, mortality occurred quickly. This is a consideration for conifer release, fire hazard, and urban situations.
6. The Gel Cap® system is simple and safe for the applicator, and it has a much greater application "window" than H & S, due to the contained herbicide.
7. Gel Cap® costs averaged $960 per hectare, compared to $285 for H & S. Gel Cap® should not be evaluated by economics alone, rather consideration should be given to regulatory, environmental, political, or biological factors, as well as work scheduling.

APPENDIX I

Gel Cap® Demonstration Trial

F-52-42-102

Location Maps

and

Plot Detail Maps

LEGEND

Fence

Slope Break

Creek

Type Change

0 km UBC Farm office
3.5 R @ Jct Hamm Rd & Hwy 19 S
0 km Hamm Rd Jct.
0.1 R @ Mc Cauley Rd
5.0 #3080 Mc Cauley Rd (locked gate)
6.3 Left fork
6.6 Stay Left @ Douglas fir, thru gate, around E side of field to site (2WD access)

AIR PHOTOS ; BC 88084
BC 88197

FOREST RESOURCE DEVELOPMENT AGREEMENT

PACE CHEMICALS LTD.

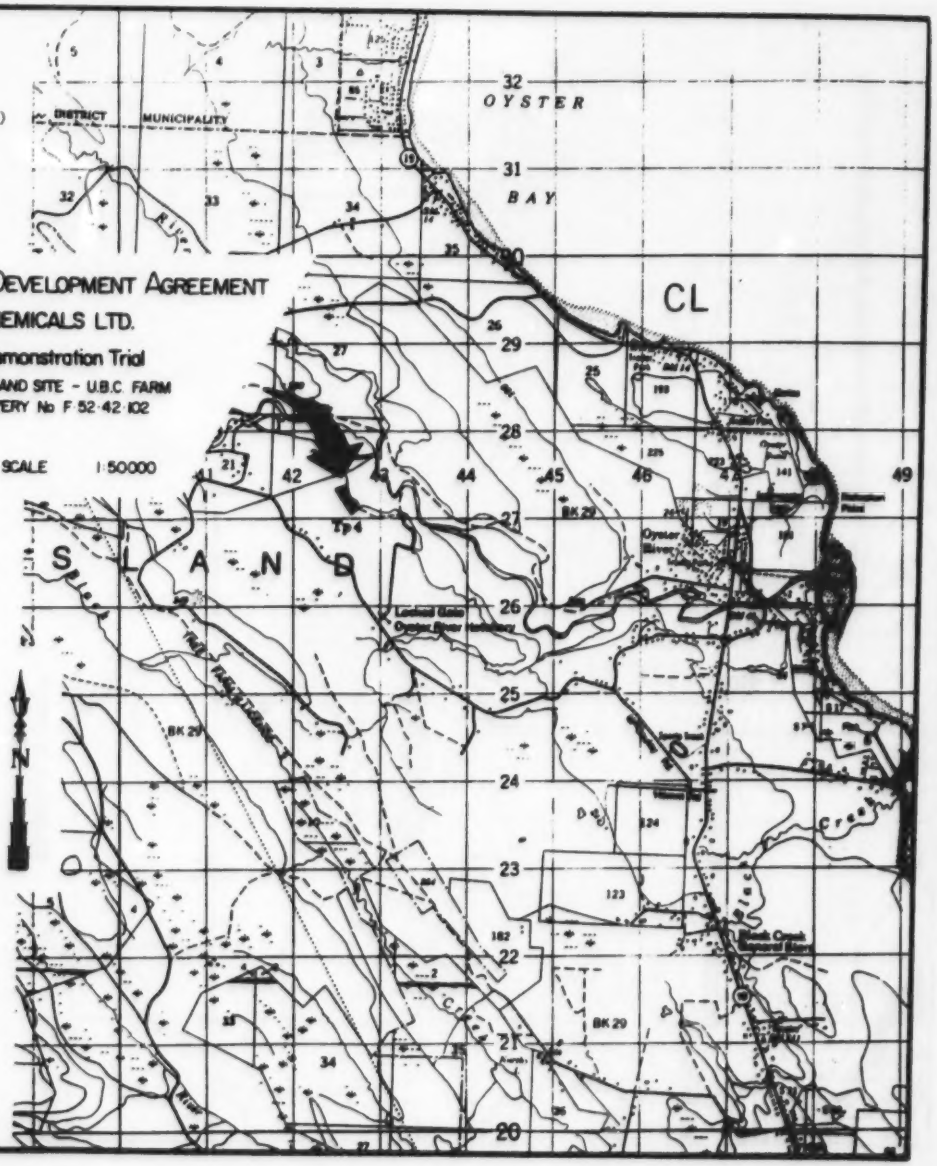
Gel Cap Demonstration Trial

VANCOUVER ISLAND SITE - U.B.C FARM
DIRECT DELIVERY No F 52-42-102

1:2000 SCALE 1:50000

PLOT DETAIL

PLOT = 400 m²
SUBPLOT = 100 m²
r = 5.65 m
20 m



0.0 km	Gate
1.0 km	"G" Road (left)
1.7 km	"G" Road (left)
4.3 km	Jct. "G" Rd. & "G10"
4.9 km	Landing on site

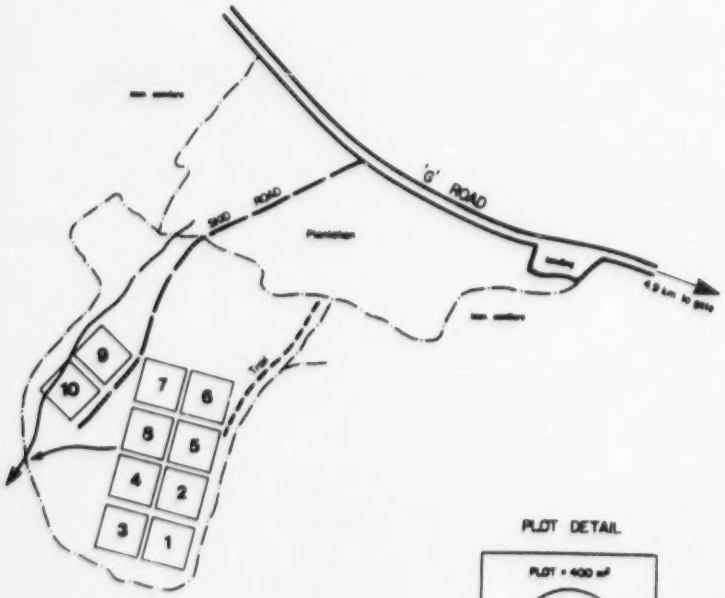
FOREST RESOURCE DEVELOPMENT AGREEMENT

PACE CHEMICALS LTD.

Gel Cap Demonstration Trial

U.B.C. MALCOLM KNAPP RESEARCH FOREST
DIRECT DELIVERY No F 52 42 102

1 2000 SCALE 1 50000



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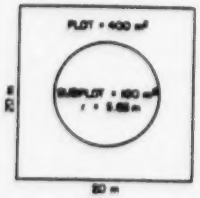
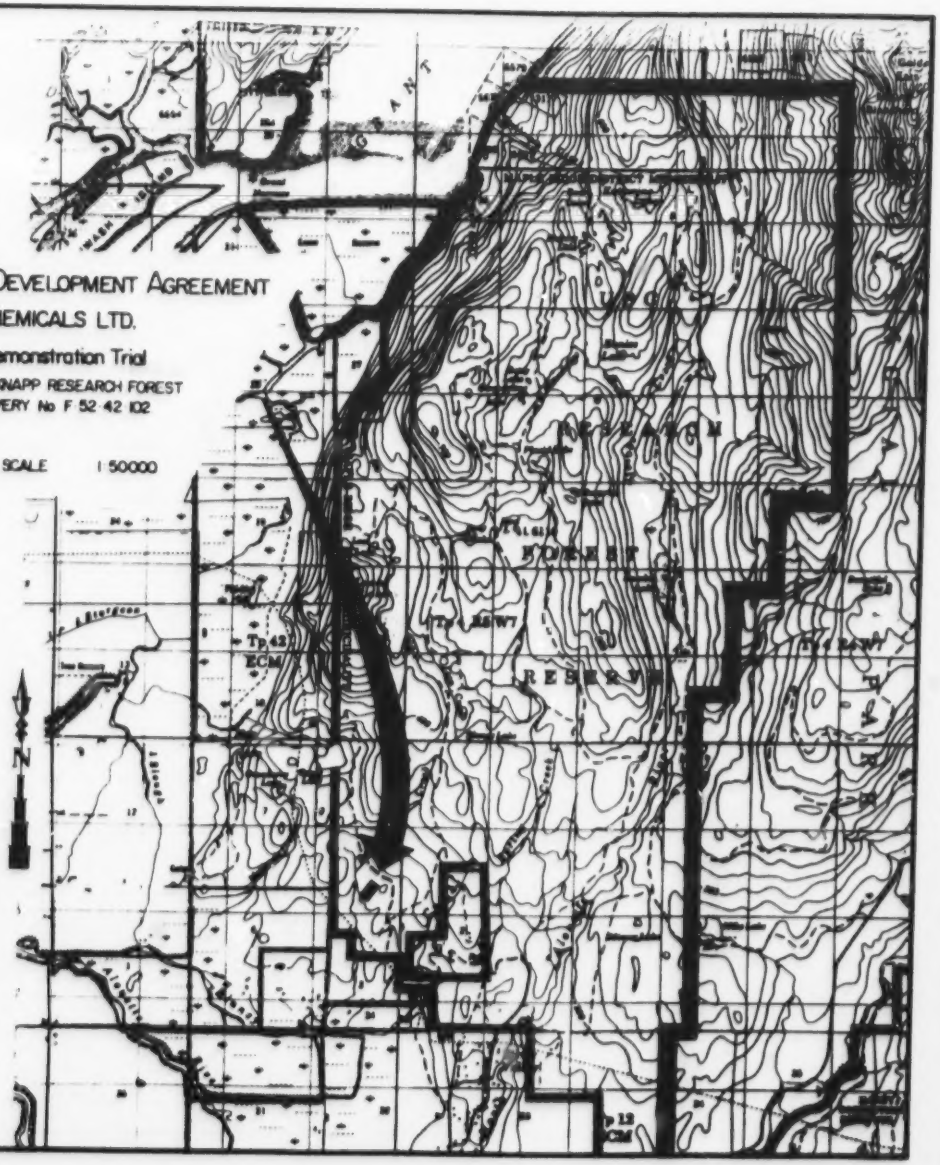
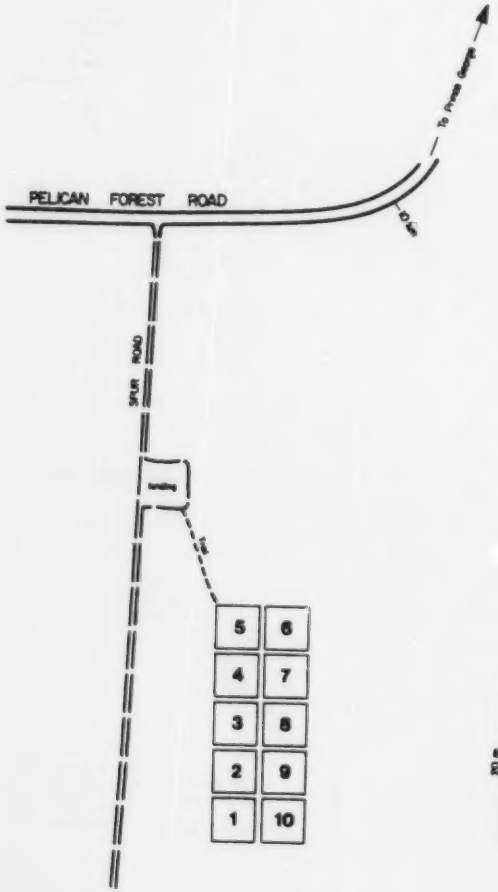




0.0 km	Jct. Hwy. 16W & Hwy. 97
9.4 km	Jct. Hwy. 16W & Blackwater Rd.
21.9 km	Jct. Blackwater Rd. & Pelican Forest Rd. (0.0 km)
2.5 km	Take left fork
6.0 km	Shesta Lake Rec. site
10.0 km	Take next left



FOREST RESOURCE DEVELOPMENT AGREEMENT

PACE CHEMICALS LTD.

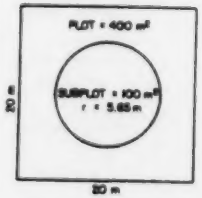
Gel Cap Demonstration Trial

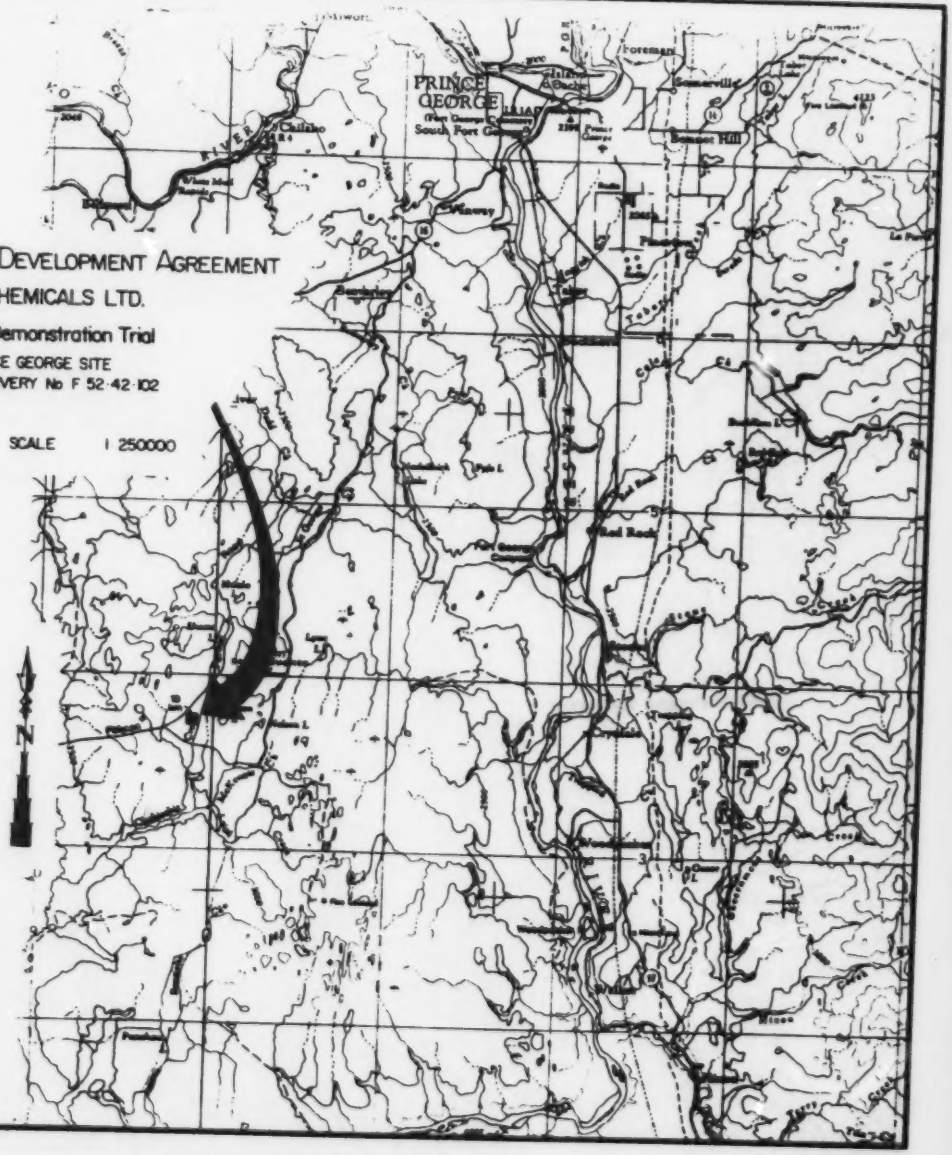
PRINCE GEORGE SITE

DIRECT DELIVERY No F 52-42-102

1 2000 SCALE 1 250000

PLOT DETAIL





FOREST RESOURCE DEVELOPMENT AGREEMENT

PACE CHEMICALS LTD.

Gel Cap Demonstration Trial

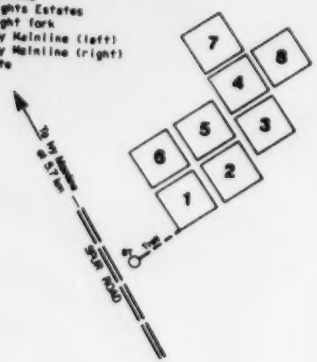
SALMON ARM SITES

DIRECT DELIVERY No. F-52-42-102

1:2000 SCALE 1:250000

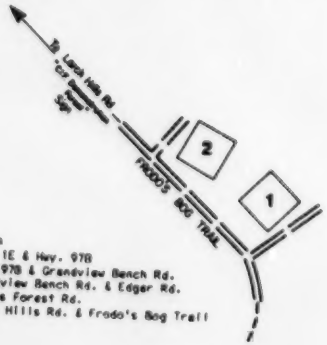
WHITE LAKE SITE

0.0 km	Salmon Arm
25.0 km	Jct. Hwy. 1W & Belmoral Chevron (right)
43.4 km	Jct. Eagle Bay Rd. & Ivy Rd. (right)
0.0 km	Ivy Mainline
0.6 km	Ivy Heights Estates
2.6 km	Take right fork
2.7 km	Jct. Ivy Mainline (left)
5.7 km	Jct. Ivy Mainline (right)
6.0 km	Demo site

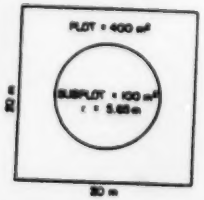


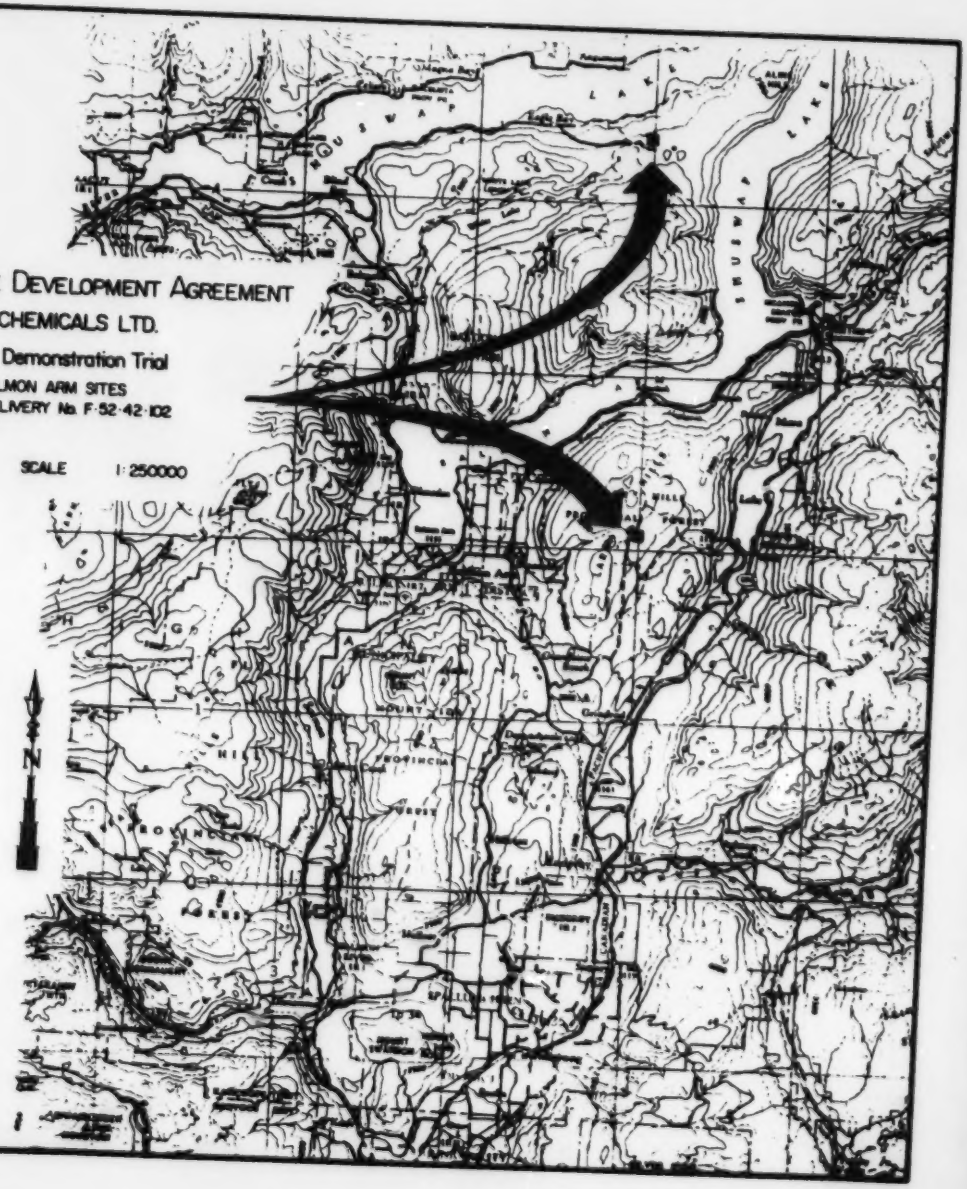
LARCH HILLS X-COUNTRY SKI TRAILS

0.0 km	Salmon Arm
5.4 km	Jct. Hwy. 1E & Hwy. 97B
14.3 km	Jct. Hwy. 97B & Grandview Bench Rd.
19.6 km	Jct. Grandview Bench Rd. & Edger Rd.
23.2 km	Larch Hills Forest Rd.
27.5 km	Jct. Larch Hills Rd. & Frodo's Bog Trail



PLOT DETAIL





APPENDIX II

Gel Cap® Demonstration Trial

F-52-42-102

Stand and Productivity Data

Tables #1 - 7

Table 1 - Stand data*

Site	Hardwood				Target Species	Conifer
	Dbh (cm)	sph	Age (m)	Height		sph
UBC Farm	12	2040	30	15	Alder	nil
UBC Forest	8	2060	16	13	Alder, willow, cottonwood	100
Prince George	5	4130	21	11	Aspen, alder, willow	1100
Salmon Arm	6	2250	18	11	Aspen, birch, willow, maple	800

* Dbh - diameter breast height
Sph - stems per hectare

Table 2 - Productivity Statistics Summary

Site	Method[3]	Product (ml) per hr.	Product (ml) per ha.	Hours per ha.	$ per hectare Product[1]	Labour[2]	Total
UBC Farm	Gel Cap®	360	4100	11.4	740	225	965
				t = 14.6*			
	H & S	180	3500	19.2	40	385	425
UBC Forest	Gel Cap®	295	2950	10.0	530	200	730
				t = 0.37 ns			
	H & S	170	1810	10.5	20	210	230
Prince George	Gel Cap®	395	5850	14.8	1055	295	1350
				t = 1.19 ns			
	H & S	255	2750	10.8	35	215	250
Salmon Arm	Gel Cap®	520	3650	7.0	655	140	795
				t = 3.26*			
	H & S	265	2400	9.3	30	185	215
Avg.	Gel Cap®	385	4140	10.8	745	215	960
		*		t = 1.27 ns			
	H & S	210	2615	12.5	35	250	285

* statistically significant (0.05)

ns not statistically significant (0.05)

1. $0.18 per Gel Cap®; $12.00 per litre of VISION (Monsanto)

2. @ $20.00/hr.

3. Gel Cap® @ 1 capsule @ 2-6 cm. dbh; 2 @ 7-12; 3 @ 13-18.
   H & S @ 50% solution; 1 hack and squirt per 3 cm. dbh.

Table 3 - UBC Farm Productivity Data

Plot #	dbh (cm)	sph (00's)	Product /ha (ml)	hrs /ha	$/hectare Product*	Labour	Total
					Gel Cap®		
1	13.6	17	4500	10.0	810	200	1010
4	12.2	20	4325	11.7	780	235	1015
5	9.2	32	4300	11.7	775	235	1010
7	13.2	13	3775	10.8	680	215	895
9	12.7	21	3650	12.9	655	260	915
(6.0 capsules/minute; 360/hour)							
Avg	11.7	20.6	4100	11.4	740	225	965
					Hack & Squirt		
2	10.4	24	3750	18.3	45	365	410
3	10.9	19	3125	19.2	40	385	425
6	11.7	20	3500	17.5	40	350	390
8	11.8	23	4000	19.2	50	385	435
10	13.4	15	3650	21.7	45	435	480
(3 ml/minute; 180 ml/hour; 360 hacks/hour)							
Avg	11.5	20.2	3500	19.2	40	385	425

* Product - VISION; @ $0.18 per capsule; 1 ml VISION (Monsanto) per capsule. For H & S, $12.00/litre, used as a 50% solution of water and VISION (Monsanto).

dbh - diameter breast height
sph - stems per hectare
ha - hectare
Labour - @ $20.00 per hour

Table 4 - UBC Forest Productivity Data

Plot #	dbh (cm)	sph (00's)	Product /ha (ml)	hrs /ha	$/hectare Product*	Labour	Total
					Gel Cap®		
1	6.2	36	4550	15.0	820	300	1120
4	9.0	16	2500	8.3	450	165	615
6	9.5	9	1950	5.8	350	115	465
7	11.2	12	1750	5.8	315	115	450
9	7.9	39	4025	15.0	725	300	1025
112 (4.9 capsules/minute; 295/hour)							
Avg	8.0	2240	2950	10.0	530	200	730
					Hack & Squirt		
2	8.4	17	2375	11.7	30	235	265
3	8.3	24	2625	12.5	30	250	280
5	10.5	12	950	7.5	10	150	160
8	13.4	8	800	7.5	10	150	160
10	7.6	33	2300	13.3	30	265	295
(2.9 ml/min; 170 ml/hour; 340 hacks/hour)							
Avg	8.9	1880	1810	10.5	20	210	230

* Product - VISION; @ $0.18 per capsule; 1 ml VISION (Monsanto) per capsule. For H & S, $12.00/litre, used as a 50% solution of water and VISION (Monsanto).

dbh - diameter breast height
sph - stems per hectare
ha - hectare
Labour - @ $20.00 per hour

Table 5 - Prince George Productivity Data

Plot #	dbh (cm)	sph (00's)	Product /ha (ml)	hrs /ha	$/hectare Product*	Labour	Total
					Gel Cap®		
1	4.3	59	5175	13.3	930	265	1195
3	5.7	32	4375	8.3	785	165	950
4	5.3	25	2925	6.7	525	135	660
5	4.6	56	6750	20.8	1215	415	1630
9	5.6	40	10025	25.0	1805	500	2305
(6.6 capsules/min; 395/hour)							
Avg	5.0	42.4	5850	14.8	1055	295	1350
					Hack & Squirt		
2	6.5	25	3125	12.1	35	240	275
6	5.9	31	2800	11.3	35	225	260
7	4.7	36	2200	8.8	25	175	200
8	4.5	36	2500	9.6	30	190	220
10	5.6	73	3125	12.1	35	240	275
(4.3 ml/min; 255 ml/hour; 511 hacks/hour)							
Avg	5.4	40.2	2750	10.8	35	215	250

* Product - VISION; @ $0.18 per capsule; 1 ml VISION (Monsanto) per capsule. For H & S, $12.00/litre, used as a 50% solution of water and VISION (Monsanto).

dbh - diameter breast height

sph - stems per hectare

ha - hectare

Labour - @ $20.00 per hour

Table 6 - Salmon Arm Productivity Data

Plot #	dbh (cm)	sph (00's)	Product /ha (ml)	hrs /ha	$/hectare Product*	Labour	Total
					Gel Cap®		
2	7.7	26	3950	7.5	710	150	860
4	6.1	25	3250	6.7	585	135	720
5	8.3	9	3000	5.0	540	100	640
8	5.6	17	3275	6.7	590	135	725
9	5.9	27	4750	9.2	855	185	1040
(8.7 capsules/minute; 520/hour)							
Avg	6.5	20.8	3650	7.0	655	140	795
					Hack & Squirt		
1	5.8	23	2200	10.0	25	200	225
3	5.9	23	2800	10.8	35	215	250
6	7.5	17	1875	6.7	25	135	160
7	6.5	30	3125	10.0	35	200	235
10	5.4	28	2000	9.2	25	185	210
(4.3 ml/minute; 255/hour; 510 hacks/hour)							
Avg	6.1	24.2	2400	9.3	30	185	215

* Product - VISION; @ $0.18 per capsule; 1 ml VISION (Monsanto) per capsule. For H & S, $12.00/litre, used as a 50% solution of water and VISION (Monsanto).

dbh - diameter breast height
sph - stems per hectare
ha - hectare
Labour - @ $20.00 per hour

Table 7 - Efficacy data summary: Percent of trees with a "foliar index scale" of 7 or more

Location	Pair #	% code 7 plus		# sample trees/plot	
		Gel Cap®	H & S	Gel Cap®	H & S
UBC FARM[a]	1	18	100	17	19
	2	77	100	21	24
	3	84	100	32	20
t = 2.83*	4	77	100	13	23
	5	66	93	21	15
	Avg	64	99	104[a]	101
UBC FOREST	1	92	96	38	24
	2	88	100	17	16
	3	100	100	8	12
t = 1.94 ns	4	83	100	12	9
	5	100	100	40	33
	Avg	93	99	115	94
	Fall treat	100	---	13	
SALMON ARM[b]	1	92	100	25	23
	2	100	100	25	24
	3	100	100	7[b]	17
t = 1.63 ns	4	100	100	16[b]	32
	5	91	100	23[b]	28
	Avg	97	100	99	124
	Fall treat	100	---	20	---
PRINCE GEORGE	1	96	100	52	49
	2	89	100	36	25
	3	75	100	28	35
t = 2.58*	4	90	100	21	34
	5	98	100	53	30
	Avg	90	100	190	173
	Fall treat	100	---	108	---
Total (excluding Fall treat)		86	100		t = 3.30*
Total (excluding UBC Farm)		93	100		t = 3.55*

a Contains large diameter (12 cm plus) trees whose bark was too thick for consistent capsule penetration

b Does not include birch. Gel Cap® cannot penetrate its bark.

* Statistically significant at 0.05 level

ns not statistically significant at 0.05 level